Butterfly disguise down to single gene

Discovery in iconic species studied by Wallace adds to evolutionary debate over mimicry.

Ewen Callaway

05 March 2014

Barrett & MacKay/All Canada Photos/Corbis

A single gene controls whether or not a female swallowtail butterfly has wing patterns resembling those of a toxic species.

The intricate disguise of the swallowtail butterfly, which mimics the wing patterns of some toxic butterfly species, is controlled by a single gene, finds a study published[1] in *Nature* today.

The finding fuels the debate about how mimicry — which helps to deter would-be predators — works. “This is a long-standing mystery in biology,” says Sean Carroll, an evolutionary developmental biologist at the University of Wisconsin–Madison, who was not involved in the study. “One of the most spectacular phenomena in nature is for two unrelated species to resemble each other.”

The disguises of the swallowtail butterfly (*Papilio polytes*) have intrigued scientists for more than 150 years. Naturalist Alfred Russel Wallace first described mimicry in females of the species in the 1860s, after travelling to southeast Asia. He used it as tangible support for the theory of evolution by natural selection, which he and Charles Darwin had formalized a few years earlier.

Butterfly mimicry was at the forefront of early-twentieth-century debates over whether such complex traits emerged gradually or in sudden, single leaps. In the 1960s, evolutionary biologists proposed that 'supergenes', sets of genes inherited en masse, were behind mimetic wing patterns, which tend to be passed to offspring either in full or not at all.

“They couldn’t fathom the idea that a single gene could do all of this,” says Marcus Kronforst, an evolutionary biologist at the University of Chicago in Illinois, who led the latest study. Male swallowtails are non-mimetic and have wings that are mostly black with white spots. But the wing patterns of females are more varied: some include striations and colourful spots that are nearly identical to those of several toxic butterfly species such as the crimson rose butterfly, *Pachliopta hector*.

Mapping traits

To uncover the genetic basis for the diversity, Kronforst’s team crossbred different populations of *P. polytes* males and females. The researchers analysed the DNA of hundreds of female offspring, and looked for regions that differed between females with mimetic wings and those without, “the same way you would map human disease traits”, says Kronfrost.

The team pinpointed a region of a chromosome that contained five genes. Further genome sequencing showed that a gene called *doublesex* determined whether females produced mimetic wings. The gene makes a protein that controls the activity of numerous other genes insects. It is also known for its influence in determining sex in fruit flies and other insects.

Krushnamegh Kunte

Mimicry helps female swallowtail butterflies deter would-be predators.

The link between *doublesex* and mimicry provides a potential explanation for why male swallowtails do not produce mimetic wing patterns: males and females are known to make different proteins by encoding and stitching together different portions of the same gene, a process called alternative splicing. But the splicing did not seem to explain the variation in female wing patterns because females, whether mimetic or not, produced the same three forms of the protein.

Location and timing

The researchers identified DNA variations in the *doublesex* gene between different forms of the swallowtail wing patterns. Many of these variations alter the properties of the proteins encoded by *doublesex*. Kronfrost suggests those differences could cause the proteins to activate different sets of genes in the developing wing to yield the various wing forms seen in females.

The debate over mimicry continues. Carroll, co-author of an article[2] that accompanies the research, suspects that 'non-coding' DNA sequences that alter the levels, location and timing at which *doublesex* acts — but not the properties of the protein — are more likely to explain its role in mimicry. Such alterations, he points out, underlie wing-spot colours in another kind of butterfly, *Heliconius*. “An educated guess from lots of other experiments is that the meaningful mutations are in regulatory sequences,” he says.

Nature | doi:10.1038/nature.2014.14820

References

1. Kunte, K. et al. *Nature* http://dx.doi.org/10.1038/nature13112 (2014).
2. Loehlin, D. & Carroll, S. *Nature* http://dx.doi.org/10.1038/nature13066 (2014).